

ABSTRACT OF THE DISCLOSURE

Disclosed herein is a barrier layer structure useful in forming copper interconnects and electrical contacts of semiconductor devices. The barrier layer structure comprises a first layer of TaN_x which is applied directly over the substrate, followed by a second layer of Ta. The TaN_x/Ta barrier layer structure provides both a barrier to the diffusion of a copper layer deposited thereover, and enables the formation of a copper layer having a high $\langle 111 \rangle$ crystallographic content so that the electromigration resistance of the copper is increased. The TaN_x layer, where x ranges from about 0.1 to about 1.5, is sufficiently amorphous to prevent the diffusion of copper into the underlying substrate, which is typically silicon or a dielectric such as silicon dioxide. The thickness of the TaN_x and Ta layers used for an interconnect depend on the feature size and aspect ratio; typically, the TaN_x layer thickness ranges from about 50 Å to about 1,000 Å, while the Ta layer thickness ranges from about 20 Å to about 500 Å. For a contact via, the permissible layer thickness on the via walls must be even more carefully controlled based on feature size and aspect ratio; typically, the TaN_x layer thickness ranges from about 10 Å to about 300 Å, while the Ta layer thickness ranges from about 5 Å to about 300 Å. The copper layer is deposited at the thickness desired to suit the needs of the device. The copper layer may be deposited using any of the preferred techniques known in the art. Preferably, the entire copper layer, or at least a "seed" layer of copper, is deposited using physical vapor deposition techniques such as sputtering or evaporation, as opposed to CVD or electroplating. Since the crystal orientation of the copper is sensitive to deposition temperature, and since the copper may tend to dewet/delaminate from the barrier layer if the temperature is too high, it is important that the copper be deposited and/or annealed at a temperature of less than about 500°C, and preferably at a temperature of less than about 300°C.